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**SAFETY EVALUATION REPORT
for the 5320 Package
for Modification of Authorized Contents**

Docket 01-11-5320

Package Approval and Safety Program
Office of Safety, Health and Security, EM-5
U.S. Department of Energy



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Introduction

A request has been made to add greater than two-year-old $^{238}\text{PuO}_2$ to the contents allowed in the existing Certificate of Compliance (CoC) [Reference 1] for the USA/5320-3/B()F (DOE) package. A Safety Analysis Report for Packaging (SARP) Supplement has been issued that addresses the limits of the proposed new contents [Reference 2]. A new CoC will be issued to cover these contents.

The package has a CoC based on the Safety Evaluation Report (SER), Docket No. 90-13-5320, of January 24, 1992 [Reference 3]. This SER will address only the SARP Supplement.

1. GENERAL INFORMATION REVIEW

1.1 Review Procedures

1.1.1 Introduction

1.1.1.1 Purpose of Application

The application addressed by this Safety Evaluation Report (SER) requests DOE approval of the use of the USA/5320-3/B()F (DOE) package to transport greater than two-year-old $^{238}\text{PuO}_2$. The application consists of a supplement to the existing 5320 SARP (Rev. 1) for which a CoC has been issued. The Staff review summarized in this SER only addresses the new contents that are not covered by the existing CoC (Rev. 16) based on the SER, January 24, 1992 [Reference 3].

Summary Information

As sintered $^{238}\text{PuO}_2$ fuel ages, the total helium produced by the alpha decay of the ^{238}Pu increases, resulting in an increase in the amount of helium present in the fuel. This helium, combined with glove box gas present at the time of the fuel loading, the gases from the decomposition from the elastomeric O-ring, and any contained water provide the total gas load within the EP-61 primary containment vessel. The decay power at the time of fuel pressing, the pressed fuel age at the time of loading into the package plus one year, and the net free volume for a specified temperature of 610 K (638°F) must result in a maximum normal operating pressure (MNOP) of less than 2.41 MPa gauge (349 psig) within the EP-61. The MNOP for the package is unchanged in the supplement to the SARP. As a result, the engineering performance of the package is unchanged due to the proposed new contents. The relationship between the allowable decay power at the time of fuel pressing, the pressed fuel age at the time of loading into the package, and the net free volume is given in Chapter 7 (Operating Procedures Review) of this SER.

The proposed contents affect only the thermal evaluation of the package (Chapter 3) and the operating procedures (Chapter 7). The structural evaluation (Chapter 2), containment evaluation (Chapter 4), shielding evaluation (Chapter 5), criticality evaluation (Chapter 6), acceptance program and maintenance evaluation (Chapter 8), and quality assurance evaluation (Chapter 9) are not affected by the shipment of the greater than two-year-old $^{238}\text{PuO}_2$ contents.

1.1.2 Package Description

1.1.2.1 Packaging

The staff finds no changes from the findings of the previous SER (Reference 3) that relate to this section.

1.1.2.2 Contents

Contents consisting of greater than two-year-old $^{238}\text{PuO}_2$ will be added to the allowed contents listed in Reference 1. The added $^{238}\text{PuO}_2$ contents will be limited by the decay power at the time of fuel pressing, the pressed fuel age at the time of loading into the package, and the net free volume for a specified temperature of 610 K (638°F) which must result in a maximum normal operating pressure of less than 2.41 MPa gauge (349 psig) within the EP-61. The relationship between the allowable decay power at the time of fuel pressing plus one year, the pressed fuel age at the time of loading into the package, and the net free volume is given in Chapter 7

(Operating Procedures Review) of this SER. The maximum decay power of the contents is limited to 203 watts at the time of pressing.

1.2 Evaluation Findings

1.2.1 Findings

Staff concludes that the application for package approval has been prepared so that:

- The packaging and its contents have been described in sufficient detail to identify the package accurately and provide a sufficient basis for evaluating the package.
- The application contains all the information required to demonstrate compliance with Subparts E and F of 10 CFR Part 71. Where alternative methods have been proposed to demonstrate compliance, sufficient information has been provided to perform an orderly review.
- The application provides sufficient information and does in fact assure compliance with requirements relating to general standards for all packages.
- The application contains a quality assurance program that conforms to Subpart H of 10 CFR Part 71.

1.2.2 Conditions of Approval

The added $^{238}\text{PuO}_2$ contents must be limited by the decay power at the time of fuel pressing to 203 watts, the pressed fuel age at the time of loading into the package plus one year, and the net free volume for a specified temperature of 610 K (638°F) which must result in a maximum normal operating pressure of less than 2.41 MPa gauge (349 psig) within the EP-61. These requirements are incorporated in the instruction given in the Executive Summary of Reference 2, which will be specified as a condition of approval in the new CoC.

The shipment of the package must be completed within a year of sealing the EP-61 primary containment vessel.

2. STRUCTURAL REVIEW

The structural review procedures are as covered by Section 3.0 of Reference 3.

3. THERMAL REVIEW

3.1 Review Procedures

3.1.1 Description of Thermal Design

3.1.1.1 Design Features

The design features are as covered by Section 4.0 of Reference 3.

3.1.1.2 Decay heat of contents

The maximum internal decay heat is 203 watts as specified in Reference 3. The added $^{238}\text{PuO}_2$ contents will be limited by the decay power at the time of fuel pressing to a maximum of 203

watts, the pressed fuel age at the time of loading into the package, and the net free volume for a specified temperature of 610 K (638°F) which must result in a maximum normal operating pressure of less than 2.41 MPa gauge (349 psig) within the EP-61. The relationship between the allowable decay power at the time of fuel pressing, the pressed fuel age at the time of loading into the package plus one year, and the net free volume is given in Chapter 7 (Operating Procedures Review) of this SER.

3.1.1.3 Codes and Standards

The codes and standards are as covered by Section 4.0 of Reference 3.

3.1.1.4 Summary Tables of Temperatures

The maximum allowable temperatures for the added contents of greater than two-year-old $^{238}\text{PuO}_2$ are 611 K (638°F) for normal conditions of transport, and 1190 K (1676°F) for hypothetical conditions.

3.1.1.5 Summary Tables of Maximum Pressures

The maximum allowable pressures in the EP-61 primary containment vessel for the added contents of greater than two-year-old $^{238}\text{PuO}_2$ are 2.41 MPa gauge (349 psig) for normal conditions of transport, and 10.5 MPa gauge (1519 psig) for hypothetical conditions.

3.1.2 Material Properties, Temperature Limits, and Component Specifications

The material properties, temperature limits, and component specifications are as covered by Section 4.0 of Reference 3.

3.1.3 General Considerations for Thermal Evaluations

The general considerations for thermal evaluations are as covered by Section 4.0 of Reference 3.

3.1.4 Thermal Evaluation under Normal Conditions of Transport

3.1.4.1 Initial Conditions

The initial conditions are as covered by Section 4.0 of Reference 3. For the added contents of greater than two-year-old $^{238}\text{PuO}_2$, the initial quantity of helium is assumed to be the total amount of helium produced from the date of pressing the pellets.

3.1.4.2 Effects of Tests

The staff finds no changes from the findings of the previous SER (Reference 3) that relate to this section.

3.1.4.3 Maximum and Minimum Temperatures

The maximum and minimum temperatures are as covered by Section 4.0 of Reference 3. For the added contents of greater than two-year-old $^{238}\text{PuO}_2$, the maximum allowable temperature is 610 K (638°F).

3.1.4.4 Maximum Normal Operating Pressure

The maximum normal operating pressure is as covered by Reference 3. For the added contents of greater than two-year-old $^{238}\text{PuO}_2$, the initial load of helium is assumed to be the total amount of helium produced from the date of pressing the pellets. The maximum normal operating pressure in the EP-61 primary containment vessel based on the initial quantity of helium plus that produced during one year from the time of placement in the package is 2.41 MPa gauge (349 psig) at 610 K (638°F).

3.1.4.5 Maximum Thermal Stresses

The maximum thermal stresses are as covered by Reference 3.

3.1.5 Thermal Evaluation under Hypothetical Accident Conditions

3.1.5.1 Initial Conditions

The initial conditions are as covered by Reference 3. For the added contents of greater than two-year-old $^{238}\text{PuO}_2$, the initial pressure is the maximum normal operating pressure of 2.41 MPa gauge (349 psig) at an initial temperature of 610 K (638°F).

3.1.5.2 Effects of Thermal Tests

The effects of the thermal tests are as covered by Reference 3.

3.1.5.3 Maximum Temperatures and Pressures

The maximum temperature and pressure are as covered by Reference 3. For the added contents of greater than two-year-old $^{238}\text{PuO}_2$, the maximum pressure is 10.5 MPa gauge (1519 psig) at a maximum temperature of 1190 K (1676°F).

3.1.5.4 Maximum Thermal Stresses

The maximum thermal stresses are as covered by Reference 3.

3.2 Evaluation Findings

3.2.1 Findings

The staff finds no changes from the findings of the previous SER (Reference 3) that relate to this section.

3.2.2 Conditions of Approval

The maximum internal decay heat is 203 watts as specified in Reference 3. The added $^{238}\text{PuO}_2$ contents must be limited by the decay power at the time of fuel pressing to 203 watts, the pressed fuel age at the time of loading into the package plus one year, and the net free volume for a specified temperature of 610 K (638°F) which must result in a maximum normal operating pressure of less than 2.41 MPa gauge (349 psig) within the EP-61. These requirements are incorporated in the instruction given in the Executive Summary of Reference 2, which will be specified as a condition of approval in the new CoC.

The relationship between the allowable decay power at the time of fuel pressing, the pressed fuel age at the time of loading into the package, and the net free volume is determined in Chapter 7 (Operating Procedures Review).

The shipment of the package must be completed within a year of sealing the EP-61 primary containment vessel.

4. CONTAINMENT REVIEW

The containment review procedures are as covered by Section 5.0 of Reference 3.

5. SHIELDING REVIEW

The shielding evaluation is as covered by Section 6.0 of Reference 3.

6. CRITICALITY REVIEW

The criticality evaluation is as covered by Section 7.0 of Reference 3.

7. OPERATING PROCEDURES REVIEW

7.1 Review Procedures

7.1.1 Package Loading

The package loading procedures are as covered by Section 8.0 of Reference 3.

7.1.2 Package Unloading

The package unloading procedures are as covered by Section 8.0 of Reference 3.

7.1.3 Other Procedures

For the added $^{238}\text{PuO}_2$ contents aged more than two years since pressing, MLM-3852 [Reference 2] identifies the following procedure:

- The decay power at the time of fuel pressing must be determined,
- The pressed fuel age at the time of loading into the package must be determined,
- And the net free volume within the EP-61 primary containment vessel after loading the EP-60 must be determined.
- For a specified temperature of 610 K (638°F), the combination of the decay power at the time of pressing, the pressed fuel age at the time of loading into the package plus one year, and the net free volume within the EP-61 after loading the EP-60 must result in a maximum normal operating pressure of less than 2.41 MPa gauge (349 psig) within the EP-61.

It is necessary to verify that the configuration, with regard to fuel quantity, pressed piece fuel age, and free void volume, does not exceed the maximum allowable pressure for normal conditions of transport (NCT). The maximum allowable pressure for NCT is 2.41 MPa gauge (349 psig). If the calculated NCT pressure based on fuel quantity, pressed piece fuel age, and free void volume exceeds 2.41 MPa gauge (349 psig), it is necessary to re-engineer the payload packaging in order to increase the free void volume, or to reduce the quantity of fuel within the package.

To determine the pressure inside the EP-61 it is necessary to know the total number of moles of gas in the EP-61, the temperature at NCT, and the continuous void volume within the EP-61.

The total number of moles of gas is the sum of the moles of cover gas, moles of gas from the decomposition of the small O-ring, moles of water from the cover gas and any sorbed water, and the moles of helium generated from the decay of ^{238}Pu . Staff agrees with the estimate of the total number of moles and molar partition from the cover gas, decomposition of the O-ring, residual water vapor, and helium produced from the time of the pellet pressing plus one year given in MLM-3852 [Reference 2].

Staff agrees that the methodology used to calculate the pressure in the EP-61 primary containment vessel given in Reference 2 is appropriate for estimating the upper bound pressure in the primary containment vessel.

7.1.4 Preparation of Empty Package for Transport

The staff finds no changes from the findings of the previous SER (Reference 3) that relate to this section.

7.2 Evaluation Findings

7.2.1 Findings

The staff finds no changes from the findings of the previous SER (Reference 3) that relate to this section.

7.2.2 Conditions of Approval

For the added $^{238}\text{PuO}_2$ contents:

- The decay power at the time of fuel pressing must be limited to 203 watts,
- The pressed fuel age at the time of loading into the package must be determined,
- And the net free volume within the EP-61 primary containment vessel after loading the EP-60 must be determined.

For a specified temperature of 610 K (638°F), the combination of the decay power at the time of pressing, the pressed fuel age at the time of loading into the package plus one year, and the net

free volume within the EP-61 after loading the EP-60 must result in a maximum normal operating pressure of less than 2.41 MPa gauge (349 psig) in the EP-61.

The above requirements are incorporated in the instruction given in the Executive Summary of Reference 2, which will be specified as a condition of approval in the new CoC.

The shipment of the package must be completed within a year of sealing the EP-61 primary containment vessel.

8. ACCEPTANCE TEST AND MAINTENANCE REVIEW

The acceptance tests and maintenance program are as covered by Section 9 of Reference 3.

9. QUALITY ASSURANCE REVIEW

The quality assurance program is as covered by Section 10 of Reference 3.

10. REFERENCES

1. CERTIFICATE OF COMPLIANCE For Radioactive Materials Packages No. 5320, Rev. 16, Package Identification No. USA/5320-3/B()F (DOE), U.S. Department of Energy, February 21, 2001.
2. MLM-3852, Supplement to Safety Analysis Report – Packages (SARP), Pu Oxide and Am Oxide Shipping Cask, DPSPU 79-124-1, Rev. 1, Supplement 1, Rev. 1, Dated 12/18/91, as amended 1/16/92 for the 5320 Shipping Cask USA/5320-3/B()F (DOE), BWXT of Ohio, Miamisburg, Ohio, September 10, 2001.
3. SAFETY EVALUATION REPORT To Resolve Three Issues that Caused Revocation of Certificate of Compliance for 5320 Package. Docket No. 90-13-5320. Transportation and Packaging Safety Safety Division, EH-33.3, U.S. Department of Energy, January 24, 1992.



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